The Hedging Effectiveness of European Style S&P 100 versus S&P 500 Index Options

Wenxi Yan

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By: **Wenxi Yan**

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Signed by the final Examining Committee:

______________________________ Chair

Dr.

______________________________ Examiner

Dr. Rahul Ravi

______________________________ Examiner

Dr. Ravi Mateti

______________________________ Supervisor

Dr. Latha Shanker

Approved by ____

Chair of Department or Graduate Program Director

Dr. Harjeet S. Bhabra

____

Dean of Faculty

Dr. Steve Harvey

Date ____

May 26th, 2014

ABSTRACT

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Wenxi Yan

This thesis examines the hedging effectiveness of European style S&P 100 index options (with the ticker symbol XEO) versus S&P 500 index options (with the ticker symbol SPX). SPX has more than thirty years of trading history. Launched on July 23, 2001, the XEO provides investors an alternative to hedge exposure to market fluctuations, especially in large-cap stocks. In my research, based on data from July 2001 to December 2011, I compare the hedging effectiveness of XEO and SPX options in hedging their underlying assets: the S&P 100 index and the S&P 500 index, respectively. The dynamic hedging strategy and the static hedging strategy are applied to construct the hedging portfolios. Based on different business cycles, I also divide the sample period into bull and bear sub-periods. The results indicate that hedging using the SPX outperforms that using the XEO, especially during the 2008 financial crisis period. This is likely because the lower trading volume in index options during the 2008 crisis period caused the XEO to lose liquidity and resulted in a worse hedging performance. I also find that the dynamic hedging strategy is more effective than the static hedging strategy over all periods. The option trading volume, time to maturity, and the implied volatility are also factors that influence the hedging effectiveness of the XEO and the SPX.

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Chapter 1. Introduction

Index options, whose underlying assets are indexes, provide investors a way to hedge the risk of fluctuation in the overall market (Tompkins, 1994). In contrast to futures, options are rights rather than obligations and provide greater flexibilities in hedging. Since the start of trading on 28th January 1983, the S&P 500 index option, with the ticker symbol SPX, currently a European-style index option, has become a commonly used index option (CBOE website). The underlying asset of the SPX is the S&P 500 index which comprises the largest 500 stocks traded on the *New York Stock Exchange* (NYSE), and *the National Association of Securities Dealers Automated Quotations* (NASDAQ). As a sub-set of the S&P 500 index, the S&P 100 index represents the performance of the major 100 blue chip companies in the US. American-style S&P 100 index options were introduced in 1983 with the ticker symbol OEX. In contrast to the SPX and OEX, the European-style S&P 100 index option (XEO) is relatively newer - launched on 23 July 2001. For equity investors with exposure to the risk from large-cap stocks and option market participants who are unwilling to undertake the risk of possible early exercise of the options on the OEX (CBOE website), XEO provides a new alternative to hedging.

Hedging is a way of reducing investment risk. Using options, hedgers are able to build a variety of hedging strategies. Hedging also plays a central role in option pricing theory. Since Black and Scholes (1973) and Merton (1973) came up with the option pricing formula that relates an option’s price to the value of its underlying asset, the determinants of the option price have been better understood and applied in practice to build hedging portfolios. Dynamic delta hedging is one of the most commonly used hedging strategies (Clewlow and

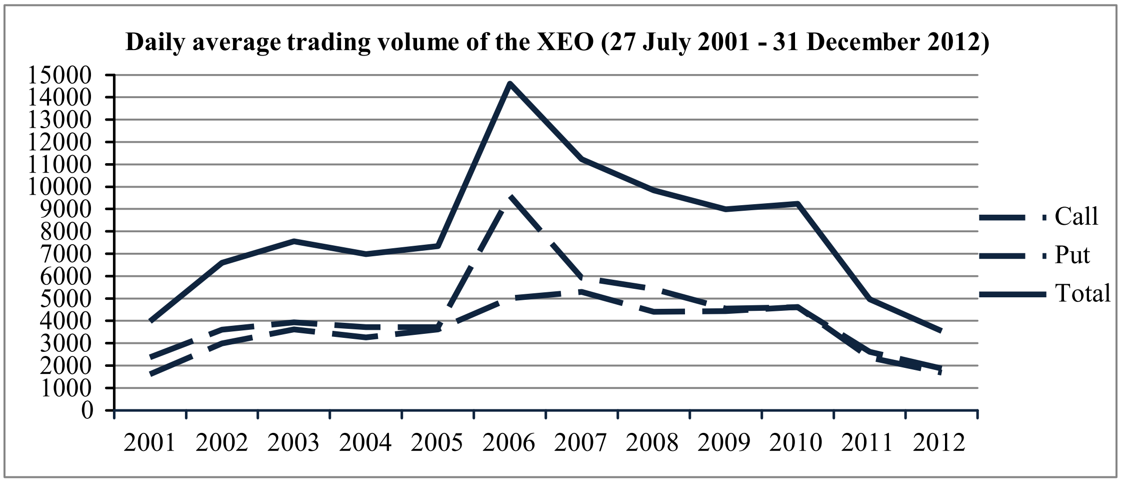
Hodges, 1997; Hsln et al., 1994). Delta is the rate of change of the option price with respect to a change in the underlying asset price, which is, in other words, the first derivative of the option pricing formula relating the option price to its underlying asset price (Black and Scholes, 1973 and Merton, 1973). Since delta changes as the underlying asset price changes, delta neutral portfolios need to be rebalanced frequently.

Testing the effectiveness of option related hedging strategies is of practical interest to both market participants and researchers. However, investors cannot rebalance a portfolio instantaneously because of high transaction fees, so in dynamic delta hedging, the hedge is rebalanced daily (Hull and White, 1987). Examining the performance of daily delta hedging portfolios by using SPX data that excludes market crash periods, Bakshi and Kapadia (2003) found that the delta hedging strategy always earns positive returns and its performance is negatively related with the option's volatility. Focusing on the foreign currency market, Hull and White (1987) applied a new approach that measures the hedging effectiveness of delta, gamma and sigma hedging by calculating the standard deviation of the hedger's gain or loss during the hedging period. They concluded that gamma hedging outperformed delta hedging when options have constant implied volatilities and short maturities. Hsln et al. (1994) constructed delta and gamma hedging portfolios for currency options, and showed that dynamic hedging strategies, such as delta and gamma hedging, would perform much worse without daily rebalancing.

Nevertheless, the dynamic hedging strategy's performance depends on the option pricing model, and daily rebalancing of hedged portfolios results in high transaction costs (Broadie et al. 2009). Therefore, investors prefer to use static hedging strategies such as covered calls and protective puts. Hedged portfolios under such strategies do not depend on option pricing models and the option position does not change until the option's expiration day. Broadie et al. (2009) compared the returns of the protective put strategy and the delta hedging strategy, and found that the delta hedging strategy slightly outperformed the protective put strategy. They suggested that since the calculation of delta greatly relies on option pricing models and none of the option pricing models is perfect, the effectiveness of delta hedging suffers from model risk, indicating that constructing static portfolios is also useful when testing option's hedging effectiveness.

In 2011, the daily average trading volume for SPX and OEX was 786,630 and 26,988 contracts, respectively. Although the XEO is a young index option with a lower trading volume compared to the SPX and OEX, the liquidity of the XEO surged drastically in recent years. Figure 1 displays the XEO's average daily trading volume from 2001 to 2012. The daily average trading volume for the XEO in 2006 peaked at around 7,301 contracts; from 2001 to 2006, the daily average trading volume grew roughly four times for puts, reaching 9,590, and rose more than three times for calls. From 2007 to 2010, the daily average trading volume for the XEO hovered at a high level - around 5,000. Then the average trading volume fell to 1,774, similar to that in 2001. Furthermore, from 2001 to 2005, the monthly average trading volume of the XEO was just 10% of that of the OEX, while it reached 21% in 2006 and has since stayed at around 20%. The increase in the trading volume implies that the XEO has been gradually accepted and applied by a growing number of investors since it started to trade in 2001.

Figure 1 Daily average trading volumes of the XEO from 27 July 2001 to 31 December 2012



Source: Option Metrics database.

The existing studies on hedging effectiveness mainly focus on the SPX (e.g., Bakshi and Kapadia, 2003; Broadie et al, 2009) as well as on the foreign currency market (e.g., Hull and White, 1987; Hsln et al., 1994). However, few researchers have addressed the hedging effectiveness of the XEO. As mentioned previously, the XEO has been used by an increasing numbers of investors in recent years. Thus, the objective of this thesis is to analyze and compare the hedging effectiveness of the XEO and the SPX under different business cycles.

First, based on Black and Scholes (1973) and Merton (1973), the delta hedging strategy is applied to construct dynamic hedging portfolios. As suggested by Hull and White (1987) and Hsln et al. (1994), delta hedging strategy would be less efficient without daily rebalancing. Therefore, I rebalance the dynamic delta hedging portfolio daily. Furthermore, since delta hedging is dependent on the Black-Scholes and Merton option pricing model which therefore leads to model risk (Broadie et al., 2009), I also investigate the performance of two widely used static hedging strategies, covered calls and protective puts, which do not suffer from model risk. In this thesis, I compare the hedging effectiveness of the XEO and SPX options in hedging their underlying assets: the S&P 100 index and the S&P 500 index, respectively, over the recent ten years, from 23 July 2001 to 31 December 2011.

Second, I applied the methodology in Hull and White (1987) to measure the hedging effectiveness of hedging portfolios by calculating the standard deviation of returns of hedged portfolios over a certain period. The performance of options which differ in moneyness and maturity are studied. Then dummy variables are used to compare the hedging effectiveness of portfolios of the XEO and the SPX under two hedging strategies (dynamic and static) during different market periods. The results indicate that the hedging effectiveness of the SPX outperforms that of the XEO. In comparison with static hedging, dynamic hedging is more effective over all periods.

Third, the market exhibits distinct characteristics during bull and bear periods (Officer, 1973; Edwards and Caglayan, 2001; Wee and Yang, 2012). Hence, the hedging effectiveness of an instrument may differ in bull and bear market periods (Wee and Yang, 2012). Since the sample period in my research exceeds ten years and covers four distinct business cycles, I divide the sample period into bull and bear sub-samples based on the US Business Cycle Expansions and Contractions report by the *National Bureau of Economic Research* (NBER), and study the hedging performance of the different instruments in the different periods. The results show that the performance of both the dynamic and static hedging strategies of the XEO is significantly over the 2008 crisis period compared to the other periods. However, the performance of the dynamic hedging strategy of the SPX is not as bad as that of the XEO over the crisis period, suggesting that dynamic hedging with the SPX might offer higher liquidity and better hedging effectiveness during a market crash.

Fourth, several potential variables might influence the options' hedging performance. Chakravarty et al. (2004) suggested that option trading volume could influence the option price as well as the value of the underlying asset. Hedging using options with higher implied volatility and longer time to maturity might perform differently compared with hedging using short term options with lower volatility (Hull and White, 1987). Therefore, I address the effect of option trading volume, time to maturity, and implied volatility, and find that the option trading volume has a positive relationship with hedging effectiveness; while, portfolios of long term options with higher implied volatility have a worse hedging performance.

The remainder of this thesis is organized as follows: Chapter II provides the literature review. The data and the methodology used in the research are presented in Chapter III and Chapter IV, respectively. Chapter V reports empirical results and a discussion of the results. Chapter VI concludes the thesis and presents limitations.

Chapter 2. Literature Review

2.1 Index Options

The index option is one of the most important derivatives based on a certain index, which is a basket of stocks, and represents movement of a particular market. In contrast to futures contracts, option buyers have the right, but not the obligation, to exercise the option (Hull, 2012). The S&P 500 index option (with the ticker symbol SPX) on the underlying S&P 500 index has more than thirty years trading history and is actively used by investors and researchers: Bakshi and Kapadia (2003) constructed delta hedging portfolios by combining S&P 500 index options with the S&P 500 index; Jackwerth (2000) examined the performance of the S&P 500 index put options after the 1987 crash; Bates (2000) examined S&P 500 futures option prices after the stock market crash of October 1987; Bondarenko (2003) documented significant negative returns for put options on the S&P 500 index futures contract; Broadie et al. (2009) formed several portfolios of S&P 500 futures options, such as straddles, and examined their returns.

As a sub-set of the S&P 500, but comprising roughly 45% of the US equity market capitalization (Zhylyevskyy, 2010), the S&P 100 index represents the performance of the largest 100 stocks comprising the major 100 blue chip companies from different industries in the US in the S&P 500 index, the American-style S&P 100 index options (with the ticker symbol OEX) were introduced in 1983 (CBOE website). Although, the OEX is an American style option while most option pricing models address European options, researchers remain interested in the OEX. Day and Lewis (1992) and Fleming (1998) concluded that the implied volatility of the OEX might contain useful information for forecasting and suggested that after modifying some biases, the implied volatility of the OEX could be a useful estimator of market volatility.

In contrast to the OEX, the European style S&P 100 index option (with the ticker symbol XEO) is a relatively new derivative on the underlying S&P 100 index which started trading on 23 July 2001 (CBOE website). Since European style options can only be exercised on the last business day before the expiration date, XEO options might be cheaper than their counterpart OEX options (CBOE website), and help investors to get rid of the risk from both the large-cap exposure and possible early exercise uncertainties (Hull, 2012). Since most option pricing models are based on European style options, European style S&P 100 index options (XEO) might be superior in hedging performance to the OEX (Zhylyevsky, 2010). Based on above, XEO has been more often used by empirical researchers in recent years. For example, Yakoob (2002) collated data on two European style index options, the SPX and the XEO, to analyze the performance of three option pricing models, including the Black-Scholes model, the Absolute Diffusion model, and the Hull-White model. The author concluded that the classical Black-Scholes Option Pricing Model still performed well in comparison to the Absolute Diffusion model and the Hull-White model; although the latter two are widely considered as improved and more accurate option pricing models. The author chose implied volatility instead of historical volatility as the measure of volatility, since empirical results indicated that the use of historical volatility results in greater pricing errors than that of implied volatility. Zhylyevskyy (2010) developed a model to price American options under stochastic volatility, and applied this model to price OEX based on the parameters modified by the XEO. The results indicated that the model performed well when pricing OEX. The author also mentioned that except for different exercise styles, OEX and XEO options have the same exercise dates, minimal strike intervals, minimum ticks, cash settlement, etc.; although the trading volume of the XEO is much less than that of the SPX and OEX, XEO is still one of the most active index options in the options market. Lim and Ting (2013) developed an improved method to derive model-free option volatility which, in contrast to the Black-Scholes implied volatility, is obtained from empirical option prices instead of option pricing models. They used XEO option price data, from 23 July 2001 to 31 December 2011, to calculate model-free volatilities. The empirical results indicated that the model-free volatilities derived from the XEO are strongly negatively related to the S&P 100 index, allowing investors to forecast the S&P 100 index based on the XEO volatilities. The authors also documented that during bear markets, such as around August 2001 and July 2008, the index declined sharply while the model-free option volatility rose substantially. Additionally, in bull markets, the model-free option volatility showed a significant downward trend.

2.2 Option Hedging Strategies

Theoretically, under the risk-neutral pricing assumption, the price of an option should be its discounted expected payoff under the risk-neutral measure, which could be calculated by integrating the payoff function over a risk neutral function (Dannis and Mayhew, 2002). Tompkins (1994, Revised Edition) pointed out that the prime breakthrough of option pricing models is to define factor which influence the option price. Thus, through examining each component of the option price, investors can understand the reasons for the option price change.

After Black-Scholes (1973) and Merton (1973) developed their option pricing model that related the option price with the value of its underlying asset, and assumed that the stock price follows a lognormal distribution with constant mean and variance, their model has been intensively examined by market participants and researchers. However, in practice, the Black-Scholes model failed to explain some phenomena in the financial market, such as the "volatility smile", and in contrast to the lognormal distribution assumed in the Black-Scholes model, the distribution of the stock price observed empirically was characterized by higher kurtosis, more negative skew and more asymmetric tails (Hull, 2012).

Even though the Black-Scholes model involves flaws, it could produce solutions for a variety of option-based hedging problems and produce model-based hedging strategies (Tompkins, 1994). Among them, delta and gamma hedging strategies are widely used by financial market participants (Clewlow and Hodges, 1997). Delta is the rate of change of the option price with respect to a change in the underlying asset price (Hull, 2012). Essentially, delta can be derived as the first derivative of the function which relates option prices to the underlying asset price. In practice, delta is used to determine how many options are required to hedge the risk of the underlying asset (Tompkins, 1994). In mathematical terms, delta can be defined as the rate of change of the price of the option with respect to a change in the price of the underlying asset, and ranges from +1 to -1. The delta-hedging strategy was proposed that relied on the concept of hedging the option exactly by using the underlying asset. The delta (Δ) of a stock option is the ratio of the change in the price of the stock option to the change in the price of the underlying asset, $\Delta = \frac{\partial c}{\partial S}$ where *c* is the price of the call option and *S* is the stock price. A riskless portfolio can be created by writing a call option and holding Δ units of the stock; so that the option price change would be hedged by the price change of the stock.

Following Black and Scholes (1973), scholars began focusing on delta-hedging, and extended it to other option pricing models. Duan (1995) deemed delta-hedging as the most important use of the GARCH model and derived delta-hedging under this model. Cont et al. (2007) assessed hedging strategies, including delta-hedging and minimal variance hedging in a market where stock prices experience jumps. Frictions in the market, especially transaction costs involved in hedging, were also considered in some papers: Leland (1985) assumed proportional transaction fees in delta-hedging; Neuhaus (1989) extended the work to investigate hedging of a European call option under a cost function with a constant and proportional cost per transaction. Besides, Clewlow and Hodges (1997) developed a computational method to address hedging performance by minimizing a loss function and maximizing the expected utility. Predicting interval volatilities of stock prices, Mykland (2000) suggested a delta-hedging procedure for institutions to manage their exposure to the stock market. Bakshi and Kapadia (2003) aimed to investigate the volatility risk premium in the option market. Commonly, in financial markets, an asset would have a lower price, if it carried higher volatility risk. Nevertheless, in the option market, investors are more willing to purchase options when they face high volatility risk during the high market fluctuation period, so the market volatility risk premium of options is inconsistent with that of other assets. Building delta neutral portfolios by buying options and hedging with stocks, Bakshi and Kapadia (2003) investigated the delta hedging gains under the Black-Scholes model with both constant and GARCH stochastic volatilities. The sample period in their research was 1 January 1988 to 30 December 1995, in order to avoid the time of the market crash of 1987. They found that the delta hedging portfolios could earn positive profits, and that delta hedging with deep-out-of-the-money options had worse performance. The authors found a negative relationship between volatility and gains from delta hedging portfolios, and concluded that there is a negative market volatility risk premium in the options market and that the volatility risk premium significantly influences the gains of delta hedging portfolios. Since delta will change as market conditions change, delta hedging is a dynamic process that needs to be modified in a timely manner; otherwise the delta hedged portfolio remains risky (Bakshi and Kapadia, 2003). However, in practice, investors are unable to rebalance the portfolio every second and usually rebalance their position once a day, thus delta hedging involves potential risk (Hull, 2012).

Moreover, since none of the option pricing models are perfect, dynamic hedging strategies greatly suffer from the inevitable flaws embedded in the option pricing models; besides, daily rebalancing portfolios cause high transaction costs for dynamic hedging strategy users (Broadie et al. 2009). Static hedging strategies in which hedging portfolios would not be changed until the option expiration date were also addressed by option market participants: constructing portfolios that combine selling at-the-money and out-of-the-money puts from August 1987 to December 2000, Bondarenko (2003) suggested that portfolios could earn high profits in a long period following the 1987 financial crisis. Especially, the excess return for at-the-money puts is -39% per month and for deep out-of-the-money puts is -95%; Jensen's Alpha for at-the-money puts is extremely high, around -23% with a high significance level. The author also applied the Sharpe ratio, Treynor's ratio, and the M-squared measure to measure the put options' performance and obtained results similar to those of Jensen's Alpha. However, both classical asset pricing models, such as CAPM, and a new model suggested by the author of this paper failed to explain why the return of put options is extremely high. Following the work in Bondarenko (2003), Broadie et al. (2009) analyzed overpriced options, investigated the Black-Scholes model and the Heston (1993) stochastic volatility model, and tested the performance of some portfolios, including put-spreads, straddles, covered calls and protective puts, and delta hedging strategies. The results indicated that the average returns of option related delta hedging portfolios were insignificant. However, the return of deep-out-of-money options was extremely large, which is inconsistent with the implications of the Black-Scholes model. The authors also suggested that using portfolios including put-spreads, straddles, covered calls and protective puts, and delta hedging strategies to examine return is appropriate, indicating that constructing static portfolios is also useful when investigating the option hedging characteristics.

Various papers focused on measurement of performance and hedging effectiveness of derivatives, such as futures and options. Considering the hedging performance of the futures market, Ederington (1979) suggested a measure of hedging effectiveness which compared the volatility of the hedged portfolio with that of unhedged assets, focusing on how much risk the hedging strategy could reduce. However, Ederington (1979) did not consider the maximization of excess return. He was only concerned with minimizing risk. Following Ederington (1979), Howard and D'Antonio (1984) derived a measure that defines hedging effectiveness as the ratio of the excess return per unit of risk of the hedged portfolio. However, their method might involve mistakes if the excess return of the spot asset, which equals to the expected return of the spot asset minus the risk free rate, is less than zero. Chang and Shanker (1986) offered a correction to the hedging effectiveness measure of Howard and D'Antonio (1984). Their correction method used the absolute value of the excess return of the spot asset and would make the hedging effectiveness greater as the value of the excess return per unit of risk rises. The authors compared the hedging effectiveness of currency options and futures and indicated that after taking margin requirements and transaction costs into consideration, currency futures are superior to currency options as hedging instruments. Comparing futures and options of foreign currency, Hsln et al. (1994) concluded that the measurement in Howard and D'Antonio (1984) is similar to the Sharpe ratio and could frequently yield conflicting results. In this paper, the authors suggested a method, which is an absolute value in contrast with the ratio in Howard and D'Antonio (1984) to measure hedging effectiveness, and proved that this measurement which addresses both return and risk performs better than the measurement in Ederington (1979).

The measurement of the performance of option related hedging was also a popular topic for researchers. Hsln et al. (1994) indicated that delta hedging is a commonly used hedging strategy, not only in stock option and index option markets, but also in foreign currency and interest rate derivative markets. Hsln et al. (1994) focused on comparing the hedging effectiveness of foreign currency futures and options by using data from January 1986 to December 1989. The authors constructed both delta and gamma hedging portfolios for currency options and tested the hedging effectiveness using two methods, one introduced in Ederington (1979) and the other a new method proposed by Hsln et al. (1994). The results show that currency futures outperform currency options, and that delta and gamma hedging are far less effective without daily rebalancing. Further, the new method which focuses on risk and return works well in examining hedging performance. Jarrow and Turnbull (1994) provided methods to delta and gamma hedge using interest rate derivatives. Luciano et al. (2012) proposed a delta and gamma hedging framework to deal with uncertainty in mortality and interest rate problems faced by life insurance companies and pension funds and tested the hedging model using a sample of UK insurers. In order to help banks identify the hedging risk in foreign currency markets, Hull and White (1987) proposed a new approach to measure the hedging effectiveness of some dynamic option hedging strategies including delta hedging, and suggested that other hedging strategies including gamma hedging and sigma (also called Vega) hedging could improve hedging effectiveness in under certain conditions. The results showed that gamma hedging performed much better when the options had constant implied volatilities and short maturities, but behaved far worse than solely delta hedging or sigma hedging when the options had highly fluctuating implied volatility and a long time to maturity.

2.3 Bull versus Bear Markets

The cycles of the financial market could be described by alternating bull and bear markets (Pagan and Sossounov, 2002). The approach used to distinguish bull and bear markets in different studies varies. Chauvet and Potter (2000) defined a bull (bear) market as a period in which stock prices continue to increase (decrease). Another definition by Pagan and Sossounov (2002) is that if the market increases (decreases) more than 20% or 25%, it is a bull (bear) market. Founded in 1920, the *National Bureau of Economic Research* (NBER) has been deemed as the largest leading national economic research organization in the US and provided the start and the end time of economic recessions for researchers (NBER website).

Since the financial market behaves differently over various business cycles, many researchers focused on the comparison of financial phenomena between bull and bear markets. Moreover, compared with the findings in quiet periods, much of the existing literature provides interesting results after separating the market into bull and bear periods (e.g. Wee and Yang, 2012 and Edwards and Caglayan, 2001). For example, Officer (1973) found that the volatility of stock returns was higher during the years around the 1930s depression. Schwert (1989) showed that stock volatility increased for brief periods during and immediately following the major financial crises. Chan and Fong (2000) showed that the number of trades, size of trades, and order imbalance explain the volatility of the New York Stock Exchange and Nasdaq stocks by using data from July to December 1993. Wee and Yang (2012) found results contrary to those of Chan and Fong (2000) after breaking down the overall period into bull and bear periods. Using data from the Australian Securities Exchange from October 2006 to September 2008 and dividing the period into bull (from October 2006 to September 2007), and bear, (from October 2007 to September 2008), sub-periods, Wee and Yang (2012) showed that the bull and bear markets exhibit different trading patterns and that information asymmetry between firms and financial institutions is larger in bear markets. Chen (2007) showed that in recessions, monetary policy has a larger impact on stock returns. Similarly, Jansen and Tsai (2010) found that the influence of monetary policy on stock returns is greater in bear markets than in bull markets. Furthermore, Perez-Quiros and Timmermann (2000) found that compared with large firms, small firms show significantly higher degree of information asymmetry especially across bear states. Using the Markov-switching model to capture stock return behavior in bull and bear markets, Maheu and McCurdy (2000) found that the bull market always has higher returns but lower volatility. In contrast the bear market has low returns but high volatility, and the volatility increases with duration in bear markets. Investigating the performance of various hedge funds and commodity funds under bull versus bear markets from 1990 to 1998, Edwards and Caglayan (2001) concluded that compared with hedging funds, commodity funds performed better in bear markets. Kole and Verbeek (2006) found that during the crash, the sensitivity of a firm's stock price to the market was drastically different from its normal sensitivity.

Furthermore, option markets also performed differently during depression periods. Rubinstein (1985) found that index distributions exhibited significant differences between pre-crash and post-crash periods. Bakshi and Kapadia (2003) conducted their research in a quiet period, excluding the financial crisis. Amihud et al. (1990) suggested that the financial market had less liquidity during the crash, and since everyone in the market recognized the illiquidity and claimed compensation for the extra cost, the market worsened. Testing the data immediately after the meltdown on 19 October 1987 using the GARCH model, Engle and Mustafa (1992) found that stock return volatility was less during the crash. Bates (2000) examined index option prices in the period following the October 1987 stock market crash and found that the option returns exhibited different distributions with more negative skewness during the market depression. As documented in Bates (2000), during the 1987 stock market crash, special phenomena appeared in the option market. At the beginning of the crash, out-of-the-money puts were sold at the highest prices compared to other options, such as out-of-the-money calls, which is possibly because out-of-the-money puts were deemed insurance against a downward moving market. After the market rose a little, the out-of-the-money puts were overpriced more than the out-of-the-money calls. Dannis and Mayhew (2002) found that the distribution of option prices was strikingly indifferent during high market volatility periods. The research described above indicate that option prices might perform differently under different market cycles, so it may be necessary to divide the sample period into different market cycles.

2.4 Option Trading Volume

Based on previous research, the fluctuation of the option contract trading volume could deeply affect both the option price and the movement of underlying assets. Copeland (1976) suggested a positive relationship between the absolute value of price changes and trading volume, which means that changes in the option market trading volume would potentially affect option prices. Anthony (1988) focused on the common stock and the call option reading volumes, and found that the call option market with higher trading volume might induce alterations in the option price and also induce higher activity in the underlying stock. Informed investors would trade in both the option market and the equity market, thus a crucial role of the option is to contribute to price discovery of the underlying asset (Cao et al. 2005). Based on the analyses of 60 most actively traded stock options listed on the Chicago Board Options Exchange from 1988 to 1992, Chakravarty et al. (2004) suggested that informed traders traded in both the option and the stock market, and the option trading volume will influence the option price gradually. Investigating takeover cases, Cao et al. (2005) found that the high abnormal trading volume of call options of the takeover target is related to high abnormal returns in the target stock around the takeover announcement day. The results suggest that option markets could help price discovery in the stock market.

Chapter 3. Data

I obtained the daily price and the trading volume data of the XEO (the European style S&P 100 index option), and SPX (the European style S&P 500 index option) through 23 July 2001 to 31 December 2012 from the *Option Metrics database* from *Wharton Research Data Service* (WRDS). The daily price of the two underlying index assets, including the S&P 100 index and the S&P 500 index, were obtained from the *Center for Research in Security Prices* (CRSP) database in WRDS.

The daily option price data include options with different maturities and exercise prices. The data has been screened identically on two criteria: 1. Options with both closing bid and closing ask quotes, in order to calculate the mid-price; 2. The option price should be smaller than the stock price but larger than the stock price minus the present value of the exercise price and dividends, otherwise the option price would involve an arbitrage opportunity which is inconsistent with the basic non-arbitrage assumption in the Black-Scholes model (Bakshi and Kapadia, 2003). The total observations for XEO options are 832,191, while for SPX options the number is 2,554,994.

Table 1 lists the business cycle report from *the National Bureau of Economic Research* (NBER), the largest economics research organization in the US, which provides start and end dates for economic recessions. From Table 1, "Peak" represents the point that the market reaches the comparable highest level where is the end of the bull and the start of the bear market; while "Bottom" is the point that the market reaches the lowest level where is the start of the bull and the end of the bear market. The sample period in my research covers three turning points for the market cycle in Table 1: June 2009 (Bottom), December 2007 (Peak), and November 2001 (Bottom).So the period between these points experienced distinctive market trend: the first bear market appeared from July 2001 and November 2001; then the first long-term bull market grew from December 2001 to December 2007; the second bear market was around 2008 financial crisis from January 2008 to June 2009; and the market revived from July 2009 to December 2012. Based on these truing points reported by NBER, I divide the whole sample period into four sub-periods:

1. 23 July 2001 to 30 November 2001, bear market.
2. 1 December 2001 to 31 December 2007, bull market.
3. 1 January 2008 to 30 June 2009, bear market.
4. 1 July 2009 to 31 December 2012, bull market.

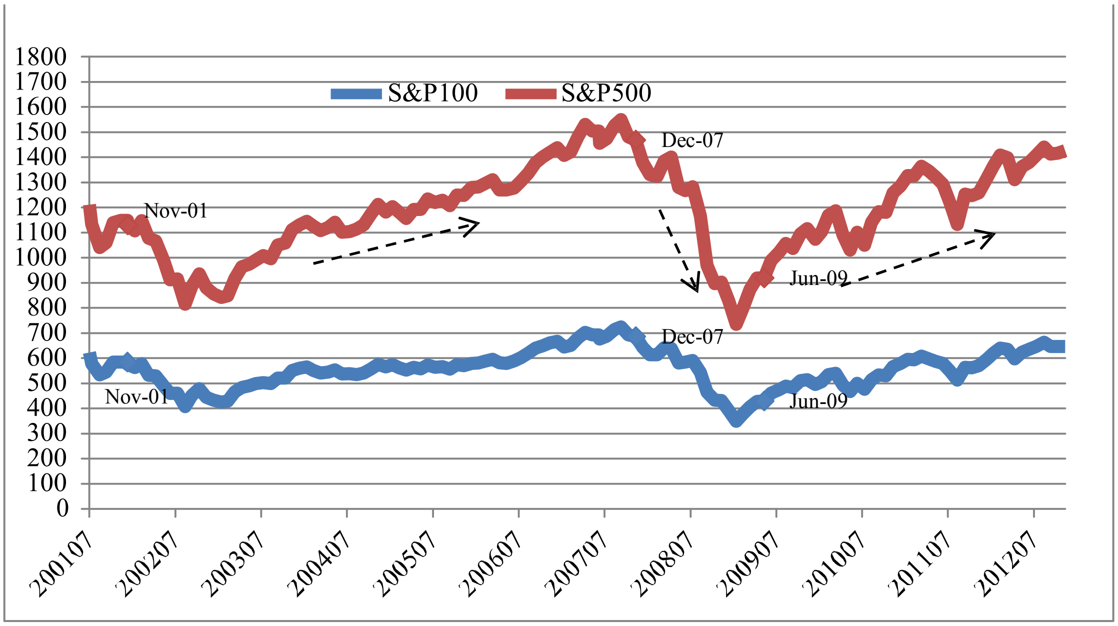
Table 1 US Business Cycle Expansions and Contractions from the National Bureau of Economic Research

Turning Point Date	Peak or Bottom
June 2009	**Bottom**
December 2007	**Peak**
November 2001	**Bottom**
March 2001	**Peak**
March 1991	Bottom
July 1990	Peak
November 1982	Bottom
July 1981	Peak
July 1980	Bottom
January 1980	Peak

Note: The bold characters denote the turning points covered in this research. Peak stands for the end of the bull and the start of the bear market, while Bottom represents the start of the bull and the end of the bear market. Source: http://www.nber.org/cycles.html

Figure 2 describes the movement in the S&P 500 and the S&P 100 index over my sample period. The market experienced a gradual increase from November 2001 to December 2007, with the S&P 500 rising roughly 400 points during six years. Nonetheless, an unexpected sharp decline happened after that, as the S&P 500 plunged from 1500 to less than 800 points within one year. Then, around June 2009, the market reached bottom and began to recover. The fluctuation of the S&P 100 follows that of the S&P 500, but shows lower volatility from 2009 to 2012.

Figure 2 Variation of the monthly S&P 100 and S&P500 index from July 2001 to December 2012



Note: The points displayed in the figure denote the turning points of the market cycle shown in Table 1. The blue area stands for the bear market periods, while the red area represents the bull market periods. Source: The Center for Research in Security Prices (CRSP) database.

Chapter 4. Methodology

<u>4.1 Hedging Strategies</u>

<u>4.1.1 Static Hedging Strategy</u>

I address two categories of static option hedging strategies which are the covered call strategy and the protective put strategy. Both of the two static hedging strategies involve a long position in an underlying stock hedged by a European style option.

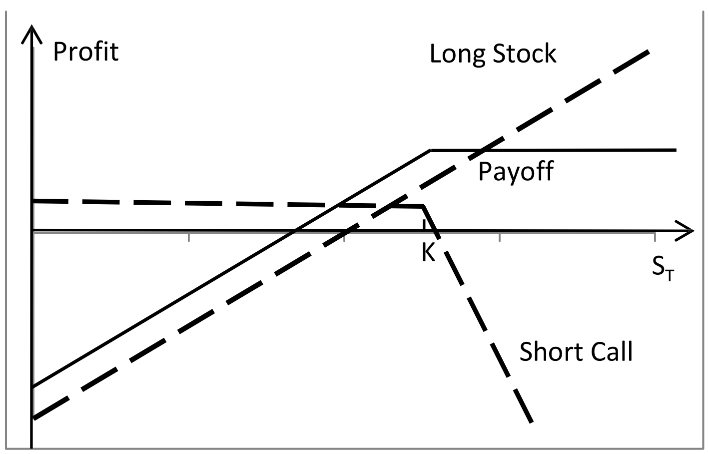
First, Figure 3 shows the profit/loss of the covered call strategy that combines a long position in the stock with a short position in the call option, which is given by (Hull, 2012):

$$�������_{?} = -(�_{?} - ��)^{+} + �_{0} + �_{0} \qquad (1)$$

$�������_{?}$ stands for the profit/loss of a covered call portfolio; $�_{?}$ is the price of the

underlying asset at the option expiration time *T*; $�_{0}$ is the price of the underlying asset at the initial time 0*; K* is the strike price of the option. Investors using this strategy first buy an underlying asset, and sell a call option; then sell the asset later at a certain strike price *K*. The underlying asset is thus partially protected from unexpected price decline.

Figure 3 Final payoff of the covered call portfolio



(Adapted from Hull, 2012)

Second, I address the protective put strategy. Figure 4 exhibits the profit/loss of the protective put portfolio that consists of a long position in the stock and a long position in the put option and could be represented by the following (Hull, 2012):

$$������_{p} = (K - �_{?})^{+} + �_{0} - �_{0}$$

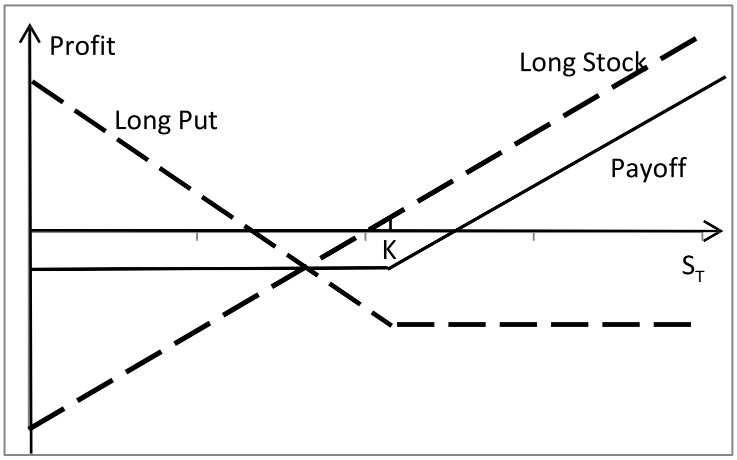
(2)

�������� represents the profit/loss of a protective put portfolio. Under this portfolio,

the

investors could eliminate the risk of a sharply declining stock price.

Figure 4 Final payoff of the protective put portfolio



(Adapted from Hull, 2012)

4.1.2 Dynamic Hedging Strategy

In Black and Scholes (1973), the Black-Scholes model assumes that the underlying asset price S follows a Brownian motion given by:

$$dS = \mu S dt + \sigma S dz \qquad (3)$$

where μ is the drift of the return of the underlying asset; σ^2 is the variance of the return;

dz is a random variable which follows a standard Wiener process and has zero mean. This model implies that the stock return *dS/S* has a normal distribution with mean μ and variance σ^2:

$$\frac{dS}{S} \sim \emptyset(\mu dt, \sigma^2 dt) \qquad (4)$$

where $\emptyset(x, y)$ represents a normal density function (*x* denotes the mean and *y* the variance). In addition, Eq. (4) implies that l�� also follows a normal distribution and �

follows a lognormal distribution. The European-style option prices for both call (*c*) and put (*p*) options under constant drift μ and constant volatility σ, could be written as (Hull, 2012):

$$c = S_0 N(d_1) - K e^{-rT} N(d_2) \tag{5}$$

$$p = K e^{-rT} N(-d_2) - S_0 N(-d_1) \tag{6}$$

where

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \tag{7}$$

$$d_2 = \frac{\ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} \tag{8}$$

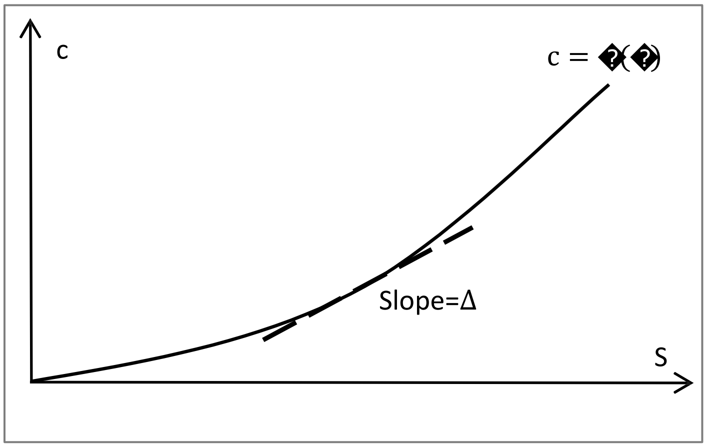
S_0 is the price of the underlying asset at time zero; *K* is the strike price of the option; σ is the volatility of the underlying asset; *r* is the continuously compounded risk free rate; *T* is the option's time to expiration and *N(x)* denotes the cumulative probability distribution function for a standardized normal distribution.

The Black-Scholes model estimates the option price as a function of six variables: the price of the underlying asset (*S*), the strike price (*K*), the volatility of the underlying asset (σ),

the

risk free rate (*r*), and the number of days until the option's expiration (*T*). Figure 5 shows the relationship between the price of the underlying asset and the price of its option, based on the Black-Scholes model, when the strike price, the volatility of *S*, the risk free rate, and the maturity time are all constant.

Figure 5 The relationship between the call option price c and the underlying asset price S



(Adapted from Hull, 2012)

The slope could be denoted as delta (Δ) that represents the first derivative of the function which relates option prices to the underlying asset and could be denoted as:

$$\Delta = \frac{\partial c}{\partial S} \tag{9}$$

where c is the price of the call option and S is the stock price. Based on the Black-Scholes model, for a European-style call option on a stock that is non-dividend-paying, delta (Δ) could be rewritten as:

$$\Delta_c = N(d_1) \tag{10}$$

For a European-style put option, it is:

$$\Delta_p = N(d_1) - 1 \tag{11}$$

Since the increase of the underlying asset price will cause the value of the call option to increase but the value of the put option to decrease, the delta for a call option is positive while for a put option it is negative. Delta neutral hedging could protect portfolios from instantaneous stock price movements during rebalancing. In this research, I build dynamic delta neutral portfolios for S&P 100 index portfolio with XEO options and for the S&P 500 index portfolio with SPX options, and rebalance those portfolios daily until the options expiration date.

4.2 Measure of Hedging Effectiveness

A method suggested by Hull and White (1987) to examine the hedging effectiveness for option hedging considers the original cost to create a hedging portfolio V_t, at time t:

$$V_t = w_{1t} c_t + w_{2t} S_t \tag{12}$$

where V_t is the cost of the hedging portfolio at time *t*; w_{1t} is the weight of the call option (*c*) in the portfolio at time *t*; w_{2t} is the weight of the underlying asset; c_t is the price of the call option at time *t*; S_t is the price of the underlying asset. If the portfolios will be changed at $t + \Delta t$, w_1 and w_2 hold constant during the period from *t* to $t + \Delta t$.

Besides,

c_t and S_t would incur interest costs at the rate r_t, thus the following represents the value of the hedged portfolio at $t + \Delta t$:

$$V(t + \Delta t) = w_{1t} c_{t+\Delta t} + w_{2t} S_{t+\Delta t} - [w_{1t} c_t + w_{2t} S_t](e^{r\Delta t} - 1)$$

Let ΔS_t and Δc_t denote changes in *S* and *c*, respectively. Hence, Hull and White (1987) denoted the gain G_1, during time Δt, of the hedger could be deemed as:

$$\Delta V_t = G_1 = w_{1t} c_{t+\Delta t} + w_{2t} S_{t+\Delta t} - [w_{1t} c_t + w_{2t} S_t] - [w_{1t} c_t + w_{2t} S_t](e^{r\Delta t} - 1) \tag{13}$$

In Hull and White (1987), the authors calculated ΔV (also written as G_1) which represents the change of the hedger’s wealth during rebalance period Δ� in equation (13). They suggested that the hedging strategies are aimed to minimize the variance of Δ� by letting Δ� close to zero. Hedging strategies with less value variance could probably represent that the value of the portfolios under such hedging strategy is stable and contains less risk during the rebalance period. They compared the $\sigma_{\Delta\pi}$ among different hedging strategies using the variance of the hedger's wealth change grouped over option maturity and moneyness by reporting the hedging effectiveness for each group respectively. Thus the hedging effectiveness (*HE*) of the hedging including *n* portfolios could be represented as (Hull and White, 1987):

$$HE = \sigma_{\pi} \tag{14}$$

σ_{π} can be represented as:

$$\sigma_{\pi} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\pi_i - \mu)^2}$$

where

$$\mu = \frac{1}{N}\left(\sum_{i=1}^{N}\pi_i\right)$$

N is the number of hedged portfolios containing options with a certain moneyness *K/S* and maturity *M* group. The hedging effectiveness represents the variance of portfolios value change, and indicates the risk level of the hedging. The higher level of the standard deviation means the higher volatility involving in the hedging and the lower hedging effectiveness.

4.3 Multivariate Regression

To compare the hedging effectiveness of the XEO and the SPX under a dynamic hedging strategy (*DH*) and a static hedging strategy (*SH*), respectively, I run multivariate regressions with dummy variables based on Brooks (1971). The regression model for comparing the hedging effectiveness (*HE*) of the XEO and the SPX under *SH* is represented as:

$$HE_{SH} = \beta_1 XEO_{SH} + \beta_2 SPX_{SH} + \varepsilon_t \qquad (15)$$

The hedging effectiveness of XEO and SPX under *DH* is

$$HE_{DH} = \beta_1 XEO_{DH} + \beta_2 SPX_{DH} + \varepsilon_t \qquad (16)$$

where *HE* is the dependent variable which is the hedging effectiveness; XEO and SPX are dummy variables with a value equal to 1 if the strategy is *SH* or *DH* respectively and 0 otherwise; the subscript *SH* and *DH* represent the static hedging strategy and dynamic hedging strategy, respectively; β_1 and β_2 are coefficients for the dummies; ε_t is a random term; from Brooks (1971), the regression with only dummy variables should have no intercept in order to avoid the 'dummy variable trap'.

Similarly, the regression model to compare the *HE* of the *SH* and *DH* could be represented as:

$$\text{��}_{X\text{��}} = \text{��}_1 \, \text{��}_{X\text{��}} + \text{��}_2 \, \text{��}_{X\text{��}} + \text{��}_t$$

(17)

$$\text{��}_{\text{��}X} = \text{��}_1 \, \text{��}_{\text{��}X} + \text{��}_2 \, \text{��}_{\text{��}X} + \text{��}_t$$

(18)

where the portfolios of XEO and SPX are addressed separately in Eq. (17) and Eq. (18), respectively; *SH* and *DH* are dummy variables with a value equal to 1 if the strategy is *SH* or

DH respectively and 0 otherwise; the subscript *XEO* and *SPX* represent hedging with XEO or SPX, respectively; the regression has zero intercept.

Then, I also run the following regressions to compare *HE* for the static and dynamic hedging strategies and for the use of the XEO and SPX as a hedging instrument during different periods:

$$HE_{XEO,SH} = \beta_1 P1_{XEO,SH} + \beta_2 P2_{XEO,SH} + \beta_3 P3_{XEO,SH} + \beta_4 P4_{XEO,SH} + \varepsilon_t \quad (19)$$

$$HE_{XEO,DH} = \beta_1 P1_{XEO,DH} + \beta_2 P2_{XEO,DH} + \beta_3 P3_{XEO,DH} + \beta_4 P4_{XEO,DH} + \varepsilon_t \quad (20)$$

$$HE_{SPX,SH} = \beta_1 P1_{SPX,SH} + \beta_2 P2_{SPX,SH} + \beta_3 P3_{SPX,SH} + \beta_4 P4_{SPX,SH} + \varepsilon_t \quad (21)$$

$$HE_{SPX,DH} = \beta_1 P1_{SPX,DH} + \beta_2 P2_{SPX,DH} + \beta_3 P3_{SPX,DH} + \beta_4 P4_{SPX,DH} + \varepsilon_t \quad (22)$$

where *P1, P2, P3* and *P4* are dummy variables which equal 1 if hedging effectiveness is for periods 1, 2, 3 and 4 respectively and zero otherwise; the regression has zero intercept as well.

Since there would be differences in the hedging effectiveness *HE* for the SPX and the XEO and also for the strategies *SH* and *DH*, I perform a multivariate regression model based on Brooks (1971), that could represent the relationship between the *HE* and three variables:

the option trading volume, time to maturity and the implied volatility, to evaluate whether the hedging effectiveness is influenced by these variables:

$$\text{��}_i = \text{���} + \text{��}_1 \text{�}V_i + \text{��}_2 \text{��}_i + \text{��}_3 \text{�}V_i + \text{��}_i$$

(23)

where *Int* stands for the Intercept; β_1, β_2 and β_3 represent the coefficients of

the

independent variables TV_i (trading volume), TM_i (time to maturity) and IV_i (implied volatility); ε_i is a random term.

Chapter 5. Results

5.1 Summary Statistics

5.1.1 Option Observations

Table 2 describes the number of option observations grouped under moneyness and maturity buckets for both XEO and SPX. 832,191 XEO options and 2,554,994 SPX options are included in the sample. Besides, the number of observations for the SPX in every bucket is roughly three times higher than that for the XEO. The larger number of observations for the SPX suggests that more SPX than XEO options are traded in the market. As shown in Table 2, more options are located in near-the-money buckets with moneyness ranging from 0.975 to 1.025, while away-from-the-money options involve fewer observations. Moreover, short-term maturity groups with maturity less than 120 days comprise 65% of the options for the XEO and 57.5% of the options for the SPX. Overall, more options in the sample are near-the-money options which have a time to maturity of less than half a year.

Table 2 The number of option observations grouped under moneyness and maturity for both the XEO and the SPX

Numbers of option observations												
	Time to Maturity (Days)											
	<15		15-60		60-120		120-300		>300		Total	
Moneyness K/S	**XEO**	**SPX**	**XEO**	**SPX**	**XEO**	**SPX**	**XEO**	**SPX**	**XEO**	**SPX**	**XEO**	**SPX**
<0.900	52,805	117,510	122,834	323,602	78,120	215,464	74,534	230,546	70,073	263,768	398,366	1,150,890
0.900-0.925	8,571	14,951	10,936	31,513	5,818	18,300	4,454	16,789	4,012	16,669	33,791	98,222
0.925-0.950	9,506	16,962	11,751	35,233	6,288	20,840	4,858	17,603	4,321	17,359	36,724	107,997
0.950-0.975	10,462	19,231	12,146	39,558	6,366	24,176	4,808	18,750	4,394	18,741	38,176	120,456
0.975-1.000	10,864	20,419	12,919	41,829	6,938	26,205	5,536	19,488	4,921	19,392	41,178	127,333
1.000-1.025	9,989	17,905	13,558	41,957	7,050	25,031	5,296	19,835	4,979	18,825	40,872	123,553
1.025-1.050	7,154	14,241	13,552	37,902	7,272	22,803	5,504	19,779	5,249	18,512	38,731	113,237
1.050-1.075	5,349	11,205	13,202	30,874	7,528	21,392	5,634	19,027	5,359	18,427	37,072	100,925
>1.075	17,207	44,135	44,564	129,878	29,641	106,564	33,203	153,449	42,666	178,355	167,281	612,381
Total	131,907	276,559	255,462	712,346	155,021	480,775	143,827	515,266	145,974	570,048	832,191	2,554,994

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011.

5.1.2 Implied Volatility

Table 3 provides descriptive statistics on the average implied volatilities for each group over different moneynesss and maturity combinations. On average, within the same maturity group, average implied volatilities for near-the-money options are generally lower than those for away-from-the-money options. For example, the implied volatility for the XEO in the first maturity group (< 15 days) in the first moneyness bucket (< 0.900) is 0.7044 which is close to that in the last moneyness bucket (> 1.075), 0.7447. As the moneyness increases, the implied volatility first decreases and then increases, reaching the minimum of 0.2635 in the near-the-money moneyness group (0.975-1.000). Thus the volatility smile is evident in in this data sample, as it is in the results of Yakoob (2002).

Table 3 Summary statistics of implied volatilities grouped under moneyness and maturity for both XEO and SPX

	Implied volatility (IV)									
	Time to Maturity (Days)									
	<15		15-60		60-120		120-300		>300	
Moneyness K/S	IV_{XEO}	IV_{SPX}	IV_{XEO}	IV_{SPX}	IV_{XEO}	IV_{SPX}	IV_{XEO}	IV_{SPX}	IV_{XEO}	IV_{SPX}
<0.900	0.7044	0.7223	0.3876	0.4198	0.3298	0.3616	0.2975	0.3212	0.2698	0.2947
0.900-0.925	0.4101	0.4071	0.2778	0.2717	0.2609	0.2559	0.2480	0.2432	0.2459	0.2367
0.925-0.950	0.3458	0.3463	0.2588	0.2509	0.2499	0.2420	0.2421	0.2342	0.2438	0.2312
0.950-0.975	0.2943	0.2943	0.2437	0.2335	0.2395	0.2297	0.2332	0.2276	0.2375	0.2272
0.975-1.000	0.2697	0.2635	0.2285	0.2167	0.2290	0.2172	0.2270	0.2198	0.2338	0.2215
1.000-1.025	0.2954	0.2779	0.2157	0.2048	0.2169	0.2080	0.2178	0.2115	0.2276	0.2159
1.025-1.050	0.3569	0.3421	0.2115	0.2018	0.2090	0.2019	0.2123	0.2052	0.2251	0.2124
1.050-1.075	0.4416	0.4009	0.2183	0.2122	0.2023	0.1952	0.2046	0.1999	0.2185	0.2074
>1.075	0.7447	0.7008	0.3131	0.3500	0.2312	0.2517	0.2118	0.2168	0.2085	0.1990

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011.

5.1.3 Hedging Effectiveness

Table 4 provides detailed statistics on the hedging effectiveness of the XEO and the SPX, respectively. Specifically, this table reports hedging effectiveness (*HE*) of XEO or SPX, based on applying dynamic and static hedging strategies over different moneyness and maturity combinations; the columns titled *Diff* describe the differences between the hedging effectivenss HE_{XEO} and HE_{SPX}, and the positive sign of *Diff* suggests that hedging portfolios of the SPX perform better than those of the XEO. Several empirical observations can be made from Table 4. First, compared with the hedging effectiveness of portfolios containing XEO, those containing SPX perform better (with positive *Diff*) in most buckets, which reveals that SPX is superior to XEO for both dynamic and static hedging strategies. Second, on average, when the option maturity holds constant, *HE* is the lowest for near-the-money options (i.e. Moneyness, $S/K \in [0.950, 1.075]$), while *HE* increases as the option's away-from-the-money level increases; the best hedging performance always occurs when the option is near the money. Third, for static hedging (Panel A of Table 4), on average, *HE* for the shortest term group (Maturity < 15) is three times lower than *HE* for the longest term group (Maturity > 300); while, for dynamic hedging (Panel B of Table 4), lower differences in the *HE* among different maturity groups are observed. A longer time to maturity is associated with worse performance for static hedging portfolios while dynamic hedging is less sensitive to the option's time to maturity.

Table 4 Summary statistics of hedging effectiveness grouped under moneyness and maturity for both XEO and SPX

Panel A: Hedging effectiveness (HE) of the static hedging strategy. Eq. (14)

Static Strategy Hedging Effectiveness (*HE*)

	Time to Maturity (Days)														
	<15			**15-60**			**60-120**			**120-300**			**>300**		
Moneyness K/S	$HE_{XEO, SH}$	$HE_{SPX, SH}$	*Diff*	$HE_{XEO, SH}$	$HE_{SPX, SH}$	*Diff*	$HE_{XEO, SH}$	$HE_{SPX, SH}$	*Diff*	$HE_{XEO, SH}$	$HE_{SPX, SH}$	*Diff*	$HE_{XEO, SH}$	$HE_{SPX, SH}$	*Diff*
<0.900	4.5806	2.2657	2.3149	6.0044	5.9669	0.0375	6.6644	6.5798	0.0846	10.4714	9.4978	0.9736	10.8304	8.4722	2.3582
0.900-0.925	4.1548	2.1376	2.0172	5.8550	5.7970	0.0580	6.8342	6.4367	0.3975	9.9197	9.0666	0.8531	10.0756	7.7550	2.3206
0.925-0.950	3.7128	1.9340	1.7788	5.4584	5.4816	-0.0232	6.4400	6.1767	0.2633	9.4641	8.3183	1.1458	9.3029	7.5964	1.7065
0.950-0.975	3.4715	2.8366	0.6349	5.1383	5.2208	-0.0825	6.1081	5.8182	0.2899	9.0289	8.0868	0.9421	8.5723	7.8122	0.7601
0.975-1.000	3.5003	1.7048	1.7955	5.0070	4.9525	0.0545	5.9894	5.6334	0.3560	8.6234	7.1213	1.5021	7.9554	7.5036	0.4518
1.000-1.025	3.4614	1.7888	1.6726	5.0277	4.8949	0.1328	5.9479	5.6652	0.2827	8.2303	7.0069	1.2234	7.3194	7.9730	-0.6536
1.025-1.050	3.6817	1.8609	1.8208	4.8962	4.9518	-0.0556	6.0737	5.7162	0.3575	8.0437	6.3728	1.6709	6.6666	7.7742	-1.1076
1.050-1.075	5.4960	5.6372	-0.1412	5.2385	8.8042	-3.5657	6.3805	9.7836	-3.4031	9.0199	12.1923	-3.1724	9.2439	8.1445	1.0994
>1.075	7.7683	2.5839	5.1844	11.9255	5.5933	6.3322	14.4845	7.9608	6.5237	20.0072	10.8532	9.1540	25.4965	11.1643	14.3322

Panel B: Hedging effectiveness (HE) of the dynamic hedging strategy. Eq.(14)

Dynamic Strategy Hedging Effectiveness (*HE*)

	Time to Maturity (Days)														
	<15			**15-60**			**60-120**			**120-300**			**>300**		
Moneyness K/S	$HE_{XEO, DH}$	$HE_{SPX, DH}$	*Diff*	$HE_{XEO, DH}$	$HE_{SPX, DH}$	*Diff*	$HE_{XEO, DH}$	$HE_{SPX, DH}$	*Diff*	$HE_{XEO, DH}$	$HE_{SPX, DH}$	*Diff*	$HE_{XEO, DH}$	$HE_{SPX, DH}$	*Diff*
<0.900	4.3446	3.0346	1.3100	2.3086	2.2196	0.0890	1.8904	2.1142	-0.2238	1.4979	1.9221	-0.4242	3.8428	1.6342	2.2086
0.900-0.925	1.9992	1.6707	0.3285	1.2576	1.2894	-0.0318	1.1865	1.1652	0.0213	1.2024	1.1305	0.0719	1.2694	1.1819	0.0875
0.925-0.950	1.6161	1.3462	0.2699	1.2093	1.154	0.0553	1.1772	1.1676	0.0096	1.1563	1.1358	0.0205	1.2290	1.1729	0.0561
0.950-0.975	1.4478	1.2936	0.1542	1.2133	1.1296	0.0837	1.1928	1.1457	0.0471	1.1719	1.1453	0.0266	1.6057	1.1828	0.4229
0.975-1.000	1.3301	1.2473	0.0828	1.2483	1.1622	0.0861	1.2382	1.1510	0.0872	1.2019	1.1509	0.0510	1.1965	1.1599	0.0366
1.000-1.025	1.3709	1.3564	0.0145	1.2688	1.2108	0.0580	1.2576	1.1876	0.0700	1.1818	1.1707	0.0111	1.1914	1.1862	0.0052

1.025-1.050	1.5350	1.4203	0.1147	1.3290	1.2614	0.0676	1.3046	1.2126	0.0920	1.2761	1.1635	0.1126	1.6711	1.1708	0.5003
1.050-1.075	1.6623	1.5337	0.1286	1.3648	1.3436	0.0212	1.2990	1.2505	0.0485	1.2178	1.2123	0.0055	3.6968	1.2338	2.4630
>1.075	5.6283	2.2293	3.3990	2.6548	2.4102	0.2446	2.2952	2.2769	0.0183	2.3147	1.9610	0.3537	2.9460	1.7698	1.1762

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. Diff stands for the difference between the hedging effectiveness of the XEO and of the XEO.

5.1.4 Option Trading Volume

Table 5 displays the options' trading volume. For near-the-money groups, with moneyness ranging from 0.950 to 1.025, the options have substantially higher trading volume. For example, for the XEO with a maturity less than 15 days, the average trading volume was 168.03 contracts for options with the moneyness from 0.975 to 1.000, more than 50 times the trading volume for option with the moneyness less than 0.900. Moreover, longer-term options have substantially lower trading volume than shorter-term options. More specifically, in the same moneyness range $S/K \in [0.950, 1.025]$, shortest-term options (Maturity < 15) have 10 times more trading volume than the longest-term options (Maturity > 300) for the SPX, while for the XEO, the difference is even larger. The finding suggests that near-the-money options with short times to maturity are more actively traded and have higher liquidity for both the XEO and the SPX.

Table 5 Summary statistics of the average option contract trading volume grouped under moneyness and maturity for both XEO and SPX

The average option contract trading volume (*TV*)										
	Time to Maturity (Days)									
	<15		15-60		60-120		120-300		>300	
Moneyness K/S	TV_{XEO}	TV_{SPX}	TV_{XEO}	TV_{SPX}	TV_{XEO}	TV_{SPX}	TV_{XEO}	TV_{SPX}	TV_{XEO}	TV_{SPX}
<0.900	3.04	100.62	5.33	131.01	2.16	91.33	0.83	59.45	0.66	41.54
0.900-0.925	8.65	318.83	12.31	469.96	3.59	253.29	0.93	211.26	0.37	88.80
0.925-0.950	16.06	619.12	19.60	791.01	4.30	312.64	1.27	233.19	0.54	84.12
0.950-0.975	34.85	1292.54	17.87	1124.04	7.50	393.85	1.39	241.59	0.89	99.74
0.975-1.000	168.03	3086.20	77.95	2191.38	18.67	1314.51	4.65	497.62	1.71	235.69
1.000-1.025	181.53	3325.48	89.46	2516.18	14.28	1611.86	3.54	608.63	0.97	256.34
1.025-1.050	44.17	1902.46	14.17	1382.96	2.62	617.14	0.96	372.28	0.60	121.94
1.050-1.075	25.05	1177.47	17.35	1265.43	3.62	529.42	0.91	347.28	0.25	86.99
>1.075	7.27	309.05	6.81	465.22	2.92	216.54	1.03	152.18	0.32	67.62

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. TV stands for the average trading volume.

Since, the overall sample period in my research covers ten years of data, from 23 July 2001 to 31 December 2011, Table 6 displays the XEO and SPX trading volume per year over different market cycles. As it was only introduced on 23 July 2001, XEO was traded at about 3,981 contracts per day during 2001. Then, the trading volume for XEO increased in the following five years, peaking at 14,603 contracts per day in 2006 with put options contributing 9,590, more than half of the total average volume. The XEO option trading volume dropped significantly after 2007. In 2011, the average daily trading volume was just 4,966, less than a third of that in 2006.

Daily trading volume for the SPX was 90,784 in 2001 and increased dramatically in the following ten years. During the crisis period, the daily volume for the SPX peaked at 711,465 in 2008, almost seven times larger than that in 2001. Then the trading volume declined but still hovered at a high level, more than 600,000 contracts, and peaked again in 2011, reaching 786,630 contracts per day. The daily trading volume of the SPX peaked during the crisis when the market also reached its peak, but unlike the XEO market, SPX market trading did not drop during the crisis period. The different trends of the trading volumes for XEO and SPX indicate that a different market liquidity trend might exist across the two option markets. The bull market in the pre-crash period from 2002 to 2006 might relate to high trading activity for the XEO, while the bear market in the crash period from 2007 to 2009 might relate to low trading volume for the XEO but high trading volume for the SPX.

Table 6 Daily average option trading volume for the XEO and the SPX from 23 July 2001 to 31 December 2011

	Year	XEO Volume				SPX Volume			
		Trading days	Call Volume	Put Volume	Total Volume	Trading days	Call Volume	Put Volume	Total Volume
Period 1: Bear market (23 Jul - 30 Nov 01)	2001	109	1,610.19	2,370.83	3,981.02	109	35,334.21	55,449.74	90,783.95
Period 2: Bull market (1 Dec 01 – 31 Dec 07)	2002	252	2,990.53	3,603.55	6,594.08	252	46,187.39	63,735.81	109,923.20
	2003	252	3,624.28	3,934.88	7,559.16	252	57,464.92	79,678.26	137,143.18
	2004	252	3,258.86	3,722.36	6,981.22	252	63,259.36	115,798.93	179,058.29
	2005	252	3,622.76	3,715.05	7,337.81	252	101,428.89	177,763.18	279,192.07
	2006	250	5,012.50	9,590.71	14,603.21	250	158,134.51	256,021.18	414,155.69
	2007	249	5,289.66	5,928.81	11,218.47	249	223,532.84	413,306.44	636,839.28
Period 3: Bear market (1 Jan 08 – 30 Jun 09)	2008	251	4,404.81	5,424.74	9,829.55	251	267,856.11	443,608.73	711,464.84
	2009	251	4,439.15	4,550.51	8,989.66	251	247,421.65	371,564.84	618,986.49
Period 4: Bull market (1 Jul 09–31 Dec 11)	2010	252	4,624.45	4,614.24	9,238.69	252	266,513.33	432,924.20	699,437.53
	2011	252	2,352.64	2,612.88	4,965.52	252	279,845.86	506,784.45	786,630.31

5.2 Comparison of Hedging Effectiveness

5.2.1 XEO and SPX

Table 7, Panel A shows the comparison of the hedging effectiveness of the XEO and the SPX using equation (15) for static hedging (*SH*), while Panel B displays the comparison of the XEO and the SPX for dynamic hedging (*DH*) by applying equation (16).

Overall, for both dynamic and static hedging, hedging with the SPX outperforms that with the XEO in most periods, and is statistically significant at the 1% level. Specifically, as seen from Panel A of Table 7, for static hedging, hedging with SPX is more effective than hedging with XEO in all periods, with the coefficients of XEO_{SH} larger than those of XEO_{SH} with 1% significance level. For dynamic hedging in Panel B of Table 7, the coefficient of XEO_{DH} is 1.3205 and that of SPX_{DH} is 1.3853 in P2 (Bull market), which are both statistically significant at the 1% level. While in P3 (Bear market) and P4 (Bull market), the SPX largely outperforms the XEO, since the coefficients of XEO_{DH} are 4.6405 (P3) and 2.9410 (P4), and those of SPX_{DH} are 3.3907 (P3) and 2.0417 (P4). The difference between the coefficients of XEO_{DH} and SPX_{DH} in P3 and P4 are both around 1.0, respectively. The conclusion is that if one applies a static hedging strategy, the SPX is better than the XEO in the four periods. However, under dynamic hedging, the performance of the XEO is comparable to that of the SPX in P2, but during the crisis period (P3) and the post-crisis period (P4), the SPX exhibits better hedging effectiveness. The results indicate that dynamic hedging with the SPX is more effective than with the XEO to hedge against market fluctuations during a crisis.

Table 7 Comparison of the hedging effectiveness of the XEO and SPX under static and dynamic hedging strategies

Panel A: Static hedging (SH) strategy.

Dummy variables	Full Sample		Period 1: Bear market 23 Jul - 30 Nov 2001		Period 2: Bull market 1 Dec 2001 - 31 Dec 2007		Period 3: Bear market 1 Jan 2008 - 30 Jun 2009		Period 4: Bull market 1 Jul 2009 - 31 Dec 2012	
	Dependent variable HE_{SH}		Dependent variable HE_{SH}		Dependent variable HE_{SH}		Dependent variable HE_{SH}		Dependent variable HE_{SH}	
	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value
XEO_{SH}	6.8205***	<.0000	4.5565***	<.0000	5.2093***	<.0000	10.0030***	<.0000	4.5684***	<.0000
SPX_{SH}	**5.1907*****	<.0000	**4.5362*****	<.0000	**4.4575*****	<.0000	**8.3124*****	<.0000	**2.2002*****	<.0000
R^2	0.4795		0.7553		0.682		0.6574		0.5805	
No. of obs.	799,391		31,630		237,853		218,343		311,565	

Panel B: Dynamic hedging (DH) strategy.

Dummy variables	Full Sample		Period 1: Bear market 23 Jul - 30 Nov 2001		Period 2: Bull market 1 Dec 2001 - 31 Dec 2007		Period 3: Bear market 1 Jan 2008 - 30 Jun 2009		Period 4: Bull market 1 Jul 2009 - 31 Dec 2012	
	Dependent variable HE_{DH}		Dependent variable HE_{DH}		Dependent variable HE_{DH}		Dependent variable HE_{DH}		Dependent variable HE_{DH}	
	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value
XEO_{DH}	3.2805***	<.0000	1.7185***	<.0000	**1.3205*****	<.0000	4.6405***	<.0000	2.9410***	<.0000
SPX_{DH}	**2.9031*****	<.0000	**1.3769*****	<.0000	1.3853***	<.0000	**3.3907*****	<.0000	**2.0417*****	<.0000
R^2	0.4085		0.3284		0.3954		0.3835		0.3739	
No. of obs.	799,391		31,630		237,853		218,343		311,565	

***denotes statistical significance at the 1% level.
** denotes statistical significance at the 5% level.
* denotes statistical significance at the 10% level.

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. In this Table, all regressions have no intercept. Panel A and Panel B are obtained by applying Eq. (15) and Eq. (16) respectively. No. of obs stands for the number of observations in the specific regression. The bold font is used to identify the strategy with better hedging effectiveness.

From the results of Panel B of Table 7 reveal that dynamic hedging using the SPX and the XEO performs differently under different market conditions. Based on the considerations above, I focus on the comparison of the hedging effectiveness of the SPX and XEO, and address the hedging of calls and puts separately. Table 8 presents the results. From Panel A and Panel B of Table 8, which provide results for static hedging, hedging portfolios of the SPX outperform those of the XEO for both calls and puts, which is consistent with the results for the static hedging reported in Panel A of Table 7.

For dynamic hedging, reported in Panel C and Panel D of Table 8, hedging portfolios of the SPX with both calls and puts outperform hedging portfolios of the XEO in most periods, while the difference is not large in P2 and P4 compared to that in P1 and P3. More specifically, hedging with XEO call options, performs substantially worse during P3 compared with other periods. In Panel A of Table 8, the coefficient of XEO is roughly three times larger than that of SPX. This difference is substantially larger than those in the other periods. While in Panel B of Table 8, the coefficient of hedging with XEO put options is larger than that of hedging with SPX put options in P3 and in P4. The results indicate that in the market crisis period (P3) and the post-crisis period (P4), hedging dynamically with both SPX calls and puts results in better hedging effectiveness; while in P2, a constant bull market before the crisis, hedging dynamically with XEO has comparable performance to that of the SPX. However, it is hard to sustain the effectiveness during the market crash, especially when hedging dynamically with XEO calls.

Table 8 Comparison of hedging effectiveness of the XEO and the SPX (calls or puts) under static and dynamic hedging strategies

Panel A: Static hedging strategy using call options.

Dummy variables	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{SH,c}$		Dependent variable $HE_{SH,c}$		Dependent variable $HE_{SH,c}$		Dependent variable $HE_{SH,c}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
$XEO_{SH,c}$	3.2128***	<.0000	2.9383***	<.0000	4.9063***	<.0000	5.6943***	<.0000
$SPX_{SH,c}$	**2.0076*** **	<.0000	**2.5725*** **	<.0000	**4.5551*** **	<.0000	**1.7298*** **	<.0000
R^2	0.5187		0.0858		0.4996		0.5967	
No. of obs.	18,212		120,030		107,172		114,666	

Panel B: Static hedging strategy using put options.

Dummy variables	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{SH,p}$		Dependent variable $HE_{SH,p}$		Dependent variable $HE_{SH,p}$		Dependent variable $HE_{SH,p}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
$XEO_{SH,p}$	3.0059***	<.0000	3.4352***	<.0000	6.7161***	<.0000	8.2664***	<.0000
$SPX_{SH,p}$	**1.4549*** **	<.0000	**2.2937*** **	<.0000	**6.0590*** **	<.0000	**3.9931*** **	<.0000
R^2	0.4741		0.6059		0.4953		0.4862	
No. of obs.	13,418		117,823		111,171		196,899	

Panel C: Dynamic hedging strategy using call options.

Dummy variables	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{DH,c}$		Dependent variable $HE_{DH,c}$		Dependent variable $HE_{DH,c}$		Dependent variable $HE_{DH,c}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**

$XEO_{DH, c}$	**1.1939*** **	<.0000	1.3178***	<.0000	10.3812***	<.0000	1.5621***	<.0000
$SPX_{DH, c}$	1.2003***	<.0000	**1.3146*** **	<.0000	**3.7592*** **	<.0000	**1.5230*** **	<.0000
R^2	0.8029		0.4319		0.3706		0.3714	
No. of obs.	13,418		117,823		111,171		196,899	

Panel D: Dynamic hedging strategy using put options.

Dummy variables	**Period 1: Bear market (23 Jul - 30 Nov 2001)**		**Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)**		**Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)**		**Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)**	
	Dependent variable $HE_{DH, p}$		**Dependent variable $HE_{DH, p}$**		**Dependent variable $HE_{DH, p}$**		**Dependent variable $HE_{DH, p}$**	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
$XEO_{DH, p}$	1.2516***	<.0000	**1.2212*** **	<.0000	6.0539***	<.0000	6.4609***	<.0000
$SPX_{DH, p}$	**1.1857*** **	<.0000	1.2726***	<.0000	**5.8741*** **	<.0000	**3.5957*** **	<.0000
R^2	0.8462		0.3668		0.4976		0.3379	
No. of obs.	13,418		117,823		111,171		196,899	

***denotes statistical significance at the 1% level.
** denotes statistical significance at the 5% level.
* denotes statistical significance at the 10% level.

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. In this Table, all regressions contain no intercept. Panel A and Panel B are obtained by applying Eq. (15); Panel C and Panel D are obtained by applying Eq. (16). No. of obs stands for the number of observations in the specific regression. The bold font is used to identify the strategy with better hedging effectiveness.

5.2.2 Dynamic and Static Hedging

Table 9 compares the hedging effectiveness of the dynamic hedging (*DH*) and static hedging (*SH*) strategies in accordance with equations (17) and (18). Panel A of Table 9 reports the comparison between *DH* and *SH* for the XEO, while Panel B compares the *DH* and *SH* for the SPX. The results reveal that dynamic hedging has better hedging effectiveness for both XEO and SPX in all periods. The regression coefficient is 3.05 for DH_{XEO} but 6.82 for SH_{XEO}, both significant at the 1% level. In other words, the hedging effectiveness of a static hedged portfolio is twice as worse as its dynamically hedged counterpart. Similarly, for the SPX, DH_{SPX} (3.3416) significantly outperforms SH_{SPX} (15.1907) by more than five times.

The findings discussed above suggest that dynamic hedging is superior to static hedging. Since static hedging might suffer due to the risks associated with options with long times to maturity, static hedging portfolios containing short-term options with maturity less than ten days are selected for closer examination. Table 10 provides comparisons between dynamic hedging *DH* and short-term static hedging $SH_{M<10}$. For both XEO and SPX, the difference between *DH* and $SH_{M<10}$ is around 0.5 over all periods, which is much smaller than the difference between *DH* and *SH*. Especially for XEO in period 4, the coefficient of *DH* is 1.7994 and that of $SH_{M<10}$ is 1.2398, suggesting that short-term SH could outperform DH. The results indicate that portfolios with long-term options negatively affect the static hedging strategy's hedging performance. Compared with static hedging, the main advantage of dynamic hedging is the portfolio daily rebalancing rule.

Table 9 Comparison of hedging effectiveness of the Dynamic Hedging (DH) and Static Hedging (SH) strategies for the XEO and SPX

Panel A: Hedging portfolios using the XEO

	Full Sample		Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable HE_{XEO}		Dependent variable HE_{XEO}		Dependent variable HE_{XEO}		Dependent variable HE_{XEO}		Dependent variable HE_{XEO}	
Dummy Variables	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value
DH_{XEO}	**3.0525*** **	<.0000	**1.7185*** **	<.0000	**1.3205*** **	<.0000	**4.6405*** **	<.0000	**2.1410*** **	<.0000
SH_{XEO}	6.8209***	<.0000	4.0565***	<.0000	5.2093***	<.0000	10.003***	<.0000	4.5684***	<.0000
R^2	0.4342		0.4853		0.7164		0.4959		0.5506	
No. of obs.	635,952		25,684		200,754		177,796		231,718	

Panel B: Hedging portfolios using the SPX

	Full Sample		Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable HE_{SPX}		Dependent variable HE_{SPX}		Dependent variable HE_{SPX}		Dependent variable HE_{SPX}		Dependent variable HE_{SPX}	
Dummy variables	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value
DH_{SPX}	**3.3416*** **	<.0000	**1.3769*** **	<.0000	**3.1853*** **	<.0000	**3.3907*** **	<.0000	**3.6753*** **	<.0000
SH_{SPX}	15.1907***	<.0000	4.5362***	<.0000	4.4575***	<.0000	8.3124***	<.0000	21.2002***	<.0000
R^2	0.4729		0.7508		0.5400		0.7366		0.5730	
No. of obs.	962,830		37,576		334,952		258,890		391,412	

***denotes statistical significance at the 1% level.
** denotes statistical significance at the 5% level.
* denotes statistical significance at the 10% level.

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. In this Table, all regressions have no intercept. Panel A and Panel B are obtained by applying Eq. (17) and Eq. (18) respectively. DH stands for dynamic hedging, which uses the Black-Scholes delta hedging strategy. SH represents static hedging, which uses the covered call and protective put hedging strategies. No. of obs stands for the number of observations in the specific regression. The bold font is used to identify the strategy with better hedging effectiveness.

Table 10 Comparison of hedging effectiveness of the Dynamic Hedging (DH) strategy and short-term Static Hedging (SH) strategy for the XEO and SPX

Panel A: Hedging portfolios containing the XEO

	Full Sample		Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable HE_{XEO}		Dependent variable HE_{XEO}		Dependent variable HE_{XEO}		Dependent variable HE_{XEO}		Dependent variable HE_{XEO}	
Dummy variables	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value			Coefficients	P-value
DH_{XEO}	**6.1841*** **	<.0000	**1.2774*** **	<.0000	**1.3231*** **	<.0000			**1.5543*** **	<.0000
$SH_{XEO(M<10)}$	6.6764***	<.0000	1.9766***	<.0000	1.4486***	<.0000			1.8640***	<.0000
R^2	0.2900		0.8496		0.8874				0.5194	
No. of obs.	286,270		12,404		92,921				80,104	

Panel B: Hedging portfolios containing the SPX

	Full Sample		Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable HE_{SPX}		Dependent variable HE_{SPX}		Dependent variable HE_{SPX}		Dependent variable HE_{SPX}		Dependent variable HE_{SPX}	
Dummy variables	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value			Coefficients	P-value
DH_{SPX}	**3.1441*** **	<.0000	**1.3833*** **	<.0000	**2.1710** **	0.0337			**3.5405*** **	<.0000
$SH_{SPX (M<10)}$	3.6896***	<.0000	1.8559***	<.0000	2.5448**	0.0049			4.0913***	<.0000
R^2	0.2890		0.8397		0.0294				0.7141	
No. of obs.	460,528		11,136		114,025				125,265	

***denotes statistical significance at the 1% level.
** denotes statistical significance at the 5% level.
* denotes statistical significance at the 10% level.

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. In this Table, all regressions contain no intercept. Panel A and Panel B are obtained by applying Eq. (17) and Eq. (18) respectively. DH stands for dynamic hedging, which uses the Black-Scholes delta hedging strategy. SH (M<10) represents static hedging with option maturities less than ten days, which applies covered call and protective put hedging strategies. No. of obs stands for the number of observations in the specific regression. The bold font is used to identify the strategy with better hedging effectiveness.

5.2.3 Hedging Effectiveness over Different Periods

This presents the results of applying equations (19) through (22). Results are presented in Table 11. The results indicate that for static hedging with SPX and XEO, in Panel A and Panel B respectively, the coefficients for P3 are the largest in magnitude and statistically significant with q p-value near zero, similar to the results for calls and puts. The comparatively higher value for $P3_{XEO,SH}$ and $P3_{SPX,SH}$ indicates that static hedging loses some effectiveness during a crisis period.

Similarly, in Panel C of Table 11, the first column indicates that the coefficient of $P3_{XEO,\ DH}$ (10.0) is two times higher than the coefficients for the other periods. After separating portfolios of calls and puts, the coefficients of $P3_{XEO,\ DH}$ are still the highest compared with those in other periods, as indicated in the 5th and 8th column, respectively. However, for the full sample regression from Panel D of Table 11, the coefficient of P4 is 3.6753, which is larger than that for P3, 3.3907. For dynamic hedging with SPX calls, the coefficient of P3 is higher than those for the other three periods; but for dynamic hedging with SPX puts, the coefficients of P2, P3 and P4 are 3.4726, 2.8741 and 3.5957, suggesting that hedging with put options does not lose hedging effectiveness during a crisis. The results are consistent with the findings in Bakshi and Kapadia (2003) that a Black-Sholes delta hedging strategy would have worse performance with option containing high volatility. The 2008 financial crisis was associated with a decrease of the underlying stock market resulting in a poor performance by option hedging due to the drastic fluctuation in the market price. Based on the evidence from Table 11, compared with dynamic hedging using the XEO, dynamic hedging using the SPX, especially SPX put options, is better performing during a crisis.

Table 11 Comparison of hedging effectiveness across four periods for the XEO or SPX under static and dynamic hedging strategies

Panel A: Static hedging strategy using the XEO.

	Full sample		Portfolios involving calls	Portfolios involving puts	
Dummy variables	**Dependent variable $HE_{XEO, SH}$**		**Dependent variable $HE_{XEO, SH, c}$**	**Dependent variable $HE_{XEO, SH, p}$**	
	Coefficients	**P-value**		**Coefficients**	**P-value**
$P1_{XEO, SH}$	1.7185***	<.0000		1.1939	0.2530
$P2_{XEO, SH}$	1.3205***	<.0000		1.3178***	0.0018
$P3_{XEO, SH}$	**4.5562******	<.0000		**10.3812******	<.0000
$P4_{XEO, SH}$	2.2173***	<.0000		1.5621**	0.0254
R^2	0.3044			0.3108	
No. of obs.	317,976			149,229	

Panel B: Static hedging strategy using the SPX.

	Full sample		Portfolios involving calls	Portfolios involving puts	
Dummy variables	**Dependent variable $HE_{SPX, SH}$**		**Dependent variable $HE_{SPX, SH, c}$**	**Dependent variable $HE_{SPX, SH, p}$**	
	Coefficients	**P-value**		**Coefficients**	**P-value**
$P1_{SPX, SH}$	4.5362***	<.0000		3.2128***	0.0018
$P2_{SPX, SH}$	4.4575***	<.0000		2.9383***	<.0000
$P3_{SPX, SH}$	**8.3124******	<.0000		**4.9063******	<.0000
$P4_{SPX, SH}$	3.2002***	<.0000		2.6943***	<.0000
R^2	0.5874			0.5758	
No. of obs.	481,415			210,851	

Panel C: Dynamic hedging strategy using the XEO.

	Full sample		Portfolios involving calls	Portfolios involving puts	
Dummy variables	**Dependent variable $HE_{XEO, DH}$**		**Dependent variable $HE_{XEO, DH, c}$**	**Dependent variable $HE_{XEO, DH, p}$**	
	Coefficients	**P-value**		**Coefficients**	**P-value**
$P1_{XEO, DH}$	4.0476***	<.0000		2.0076***	0.0005
$P2_{XEO, DH}$	5.2093***	<.0000		3.5725***	<.0000
$P3_{XEO, DH}$	**10.003******	<.0000		**6.5551******	<.0000
$P4_{XEO, DH}$	4.5684***	<.0000		1.7298***	<.0000
R^2	0.6135			0.4685	
No. of obs.	317,976			149,229	

Panel D: Dynamic hedging strategy using the SPX.

	Full sample	Portfolios involving calls	Portfolios i

Dummy variables	Dependent variable $HE_{SPX, DH}$		Dependent variable $HE_{SPX, SH, c}$		Dependent variable $HE_{SPX, SH, p}$	
	Coefficients	P-value	Coefficients	P-value	Coefficients	P-
$P1_{SPX, DH}$	1.3769***	<.0000	1.4003***	<.0000	1.1857***	<.0
$P2_{SPX, DH}$	3.1867***	<.0000	1.3746***	<.0000	3.4726***	<.0
$P3_{SPX, DH}$	3.3907***	<.0000	**3.7592*****	<.0000	2.8741***	<.0
$P4_{SPX, DH}$	**3.6753*****	<.0000	1.8230***	<.0000	**3.5957*****	<.0
R^2	0.4230		0.5444		0.3936	
No. of obs.	481,415		210,851		270,564	

***denotes statistical significance at the 1% level.
** denotes statistical significance at the 5% level.
* denotes statistical significance at the 10% level.

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. In this Table, all regressions have no intercept. Panel A, Panel B, Panel C and Panel D are obtained by applying Eq. (19), Eq. (20), Eq. (21), and Eq. (22). P1 includes portfolios from 23 July, 2001 - 30 November, 2001, Bear market. P2 includes portfolios from December 1, 2001 - December 31, 2007, Bull market. P3 includes portfolios from January 1, 2008 to June 30, 2009, Bear market. P4 includes portfolios from July 1, 2009 - December 31, 2012, Bull market. No. of obs stands for the number of observations in the certain regression. Subscript XEO denotes S&P 100 index options and SPX S&P 500 index options. Subscript SH denotes static hedging and DH dynamic hedging. The bold font is used to identify the strategy with worse hedging effectiveness

5.3 Influence of Other Variables

In this section, the relationship is examined between the index option hedging effectiveness and three variables, option trading volume (*TV*), time to maturity (*TM*), and the average implied volatility (*IV*), by regressing the *HE* of the XEO and the SPX under the two hedging strategies on the three variables mentioned above, as in equation (23). The regression results are displayed in Table 12. For both dynamic hedging and static hedging, *TV* has negative coefficients, which is consistent with the results from Chakravarty, Gulen, and Mayhew (2004), that a higher trading volume induces better hedging performance. For dynamic hedging using the XEO and SPX, the coefficients of *TM* (option maturity) are 0.0935 and -0.1117, with significance levels of 10% and 5%, respectively; while the hedging effectiveness of static hedging is more sensitive to maturity, with coefficients of *TM* of 0.9106 and 8.2206, both at the 1% significance level. The reason why static hedging performs more poorly than dynamic hedging is possibly because of the higher risk involved in the longer option holding periods. The positive coefficients of *IV* indicate that the poorer performance might be due to the higher risk of the option, which is in accordance with the findings of Bakshi and Kapadia (2003) that the performance of the delta hedging strategy is negatively related with high volatility risk.

Table 12 Influence of the trading volume, the time to maturity and the implied volatility on the hedging effectiveness of the XEO and the SPX under the Static and Dynamic hedging strategies

	Static Hedging				**Dynamic Hedging**			
	Dependent variable $HE_{XEO, SH}$		**Dependent variable $HE_{SPX,SH}$**		**Dependent variable $HE_{XEO, DH}$**		**Dependent variable $HE_{SPX, DH}$**	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
Int	9.4599***	<.0000	-5.0301***	<.0000	1.7554***	0.0067	5.5226***	<.0000
TV	-0.2606***	<.0000	-0.2507***	<.0000	-0.0640**	0.0460	-0.3564***	<.0000
TM	0.9106***	<.0000	8.2206***	<.0000	0.0935*	0.0972	-0.1117**	0.0165
IV	4.7713***	<.0000	8.3833***	<.0000	3.8737***	<.0000	0.3776**	0.0118
R^2	0.0907		0.2339		0.0865		0.0853	
No. of obs.	317,976		481,415		317,976		481,415	

***denotes statistical significance at the 1% level.
** denotes statistical significance at the 5% level.
* denotes statistical significance at the 10% level.

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. The results in this table are obtained by applying Eq. (23). Int stands for the intercept. TV is the natural log of the trading volume. TM is the natural log of the time to maturity. IV stands for the implied volatility calculated using the Black-Scholes model. No. of obs stands for the number of observations in the specific regression.

To see the issue more clearly, hedged portfolios are divided under call and put options and the relationship between the index option hedging effectiveness and *TV*, TM, and *IV* is addressed separately for calls and puts. Table 13 displays the regression results: the first four panels (Panel A, B, C and D) in Table 13 report the regression results for static hedging; while the rest (Panel E, F, G and H) contain the results for dynamic hedging.

For static hedging (Panel A, B, C and D of Table 13), *TV* has significantly negative coefficients, while coefficients for *TM* are all negative with highly significant levels for hedging with the SPX and the XEO both for calls and puts over all periods, which is consistent with the results from Table 12 that higher trading volume and shorter times to maturity could positively impact hedging performance. The influences of *IV* is erratic, with insignificant p-values for regressions with XEO call and put portfolios in P1 and P2 and for SPX call portfolios in P2 and P3.

Considering the regressions for dynamic hedging, the influence of option trading volume is more significant for hedging with the SPX than with the XEO. In Panel E and F of Table 13, the coefficients of *TV* are significant at the 1% and 10% levels in P2 for the XEO calls and puts; but in P3, *TV* is uncorrelated with the performance of the portfolios with the XEO calls with p-value > 0.1. In P4, *TV* becomes uncorrelated with hedging performance for both XEO calls and puts.

Apart from the results for dynamic hedging using the XEO, dynamic hedging using the SPX, which are shown in Panels G and H of Table 13, represent a higher associated between hedging performance and trading volume for both call and put hedging portfolios in all periods. Especially in P3, the coefficients for *TV* are -0.2860 and -0.0082 with a 1% significant level, suggesting that unlike the performance of dynamic hedging using the XEO, the performance of dynamic hedging using the SPX is more sensitive to trading volume, even during the financial crisis, and the higher trading volume contributes to better hedging performance for dynamic hedging with the SPX.

Table 13 Influence of trading volume, maturity and implied volatility on hedging effectiveness of the XEO and SPX (calls and puts) in four periods using Static or Dynamic hedging strategies

Panel A: Static hedging using XEO call options.

	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{XEO, SH, c}$		Dependent variable $HE_{XEO, SH, c}$		Dependent variable $HE_{XEO, SH, c}$		Dependent variable $HE_{XEO, SH, c}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
Int	-0.7657	0.5443	-1.4695*	0.0634	1.6914***	<.0000	1.1411**	0.0119
TV	-0.6428***	<.0000	-0.3404***	<.0000	-0.4028***	<.0000	-0.0242*	0.0866
TM	1.1059***	0.0001	1.1738***	<.0000	1.7639***	<.0000	0.3838***	<.0000
IV	0.1830	0.8037	-0.4708	0.4635	6.5788***	<.0000	0.8622***	<.0000
R^2	0.4021		0.4215		0.1427		0.2312	
No. of obs.	7,001		51,609		44,941		45,678	

Panel B: Static hedging using XEO put options.

	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{XEO, SH, p}$		Dependent variable $HE_{XEO, SH, p}$		Dependent variable $HE_{XEO, SH, p}$		Dependent variable $HE_{XEO, SH, p}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
Int	-1.2813	0.2564	-0.7334	0.3372	16.2445***	<.0000	-1.8243***	0.0092
TV	-0.2961***	<.0000	-0.1275***	0.0014	-0.3846***	<.0000	-0.0859**	0.0182
TM	0.8771***	0.0003	0.5832***	<.0000	2.0472***	<.0000	1.1718***	<.0000
IV	0.6066	0.3327	1.1071	0.1124	4.9260***	<.0000	1.1318**	0.0197
R^2	0.1919		0.1276		0.1333		0.2214	
No. of obs.	5,841		48,768		43,957		70,181	

Panel C: Static hedging using SPX call options.

Period 1: Bear market (23 Jul - 30 Nov 2001)	Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)	Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)	Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)

	Dependent variable $HE_{SPX, SH, c}$		Dependent variable $HE_{SPX, SH, c}$		Dependent variable $HE_{SPX, SH, c}$		Dependent variable $HE_{SPX, SH, c}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
Int	-3.2934**	0.0156	0.3311	0.9054	-2.7490**	0.0113	2.7129	0.2648
TV	-0.4430***	<.0000	-0.1080**	0.0367	-0.5065***	<.0000	-0.2662***	0.0083
TM	1.2834***	<.0000	0.4441*	0.0941	1.3494***	<.0000	7.4507***	<.0000
IV	1.3242**	0.0294	0.3250	0.7645	0.2092	0.5877	5.1100***	<.0000
R^2	0.2797		0.0027		0.3382		0.6536	
No. of obs.	11,211		68,421		62,231		68,988	

Panel D: Static hedging using SPX put options.

	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{SPX, SH, p}$		Dependent variable $HE_{SPX, SH, p}$		Dependent variable $HE_{SPX, SH, p}$		Dependent variable $HE_{SPX, SH, p}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
Int	-5.8267***	0.0003	-6.5405***	<.0000	-6.2323***	0.0001	-2.5487***	<.0000
TV	-0.5119***	<.0000	-0.3119***	<.0000	-0.4302***	<.0000	-0.6170***	<.0000
TM	1.4382***	<.0000	1.4909***	<.0000	1.5620***	<.0000	6.1112***	<.0000
IV	1.6035**	0.0329	1.9306***	<.0000	3.7000***	<.0000	1.6416***	<.0000
R^2	0.2424		0.4394		0.0656		0.1037	
No. of obs.	7,577		69,055		67,214		126,718	

Panel E: Dynamic hedging using XEO call options.

	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{XEO, DH, c}$		Dependent variable $HE_{XEO, DH, c}$		Dependent variable $HE_{XEO, DH, c}$		Dependent variable $HE_{XEO, DH, c}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
Int	5.6358***	0.0005	1.4142***	<.0000	-5.8016***	<.0000	-0.1675	0.8572
TV	-0.1033**	0.0158	-0.0293***	0.0015	0.4094	0.3560	-0.0431	0.3165
TM	-1.0044***	0.0060	-0.0492	0.6936	8.1102***	0.0075	-0.3876	0.1205
IV	-1.6922***	0.0096	-0.0089	0.7013	3.4818***	<.0000	1.4068***	0.0001

R^2	0.1421		0.0324		0.1729		0.2601	
No. of obs.	7,001		51,609		44,941		45,678	

Panel F: Dynamic hedging using XEO put options.

	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{XEO, DH, p}$		Dependent variable $HE_{XEO, DH, p}$		Dependent variable $HE_{XEO, DH, p}$		Dependent variable $HE_{XEO, DH, p}$	
	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value
Int	2.3098**	0.0210	1.6126***	<.0000	1.8616	0.7946	5.2808	0.7196
TV	0.0200	0.4661	-0.0314*	0.0696	-0.3808*	0.0622	-0.2393	0.6590
TM	-0.4858	0.2192	-0.0896*	0.0611	4.5966	0.1641	-1.8122	0.7410
IV	-0.1514	0.5427	0.1781	0.5777	-4.0303***	0.0027	6.4763	0.2418
R^2	0.0473		0.0523		0.0565		0.0687	
No. of obs.	5,841		48,768		43,957		70,181	

Panel G: Dynamic hedging using SPX call options.

	Period 1: Bear market (23 Jul - 30 Nov 2001)		Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)		Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)		Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)	
	Dependent variable $HE_{SPX, DH, c}$		Dependent variable $HE_{SPX, DH, c}$		Dependent variable $HE_{SPX, DH, c}$		Dependent variable $HE_{SPX, DH, c}$	
	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value
Int	2.0516***	<.0000	2.1197***	<.0000	5.8030***	<.0000	3.2308***	<.0000
TV	-0.0172	0.1699	-0.0158*	0.0944	-0.1286***	<.0000	-0.1360***	<.0000
TM	-0.0922	0.1009	-0.1315**	0.0449	-0.2799**	0.0106	-0.0209	0.8127
IV	-0.5070	0.2837	-0.1345	0.4839	-0.0947	0.8020	-0.9231***	0.0029
R^2	0.0086		0.0063		0.0581		0.0528	
No. of obs.	11,211		68,421		62,231		68,988	

Panel H: Dynamic hedging using SPX put options.

	Period 1: Bear market (23 Jul - 30 Nov 2001)	Period 2: Bull market (1 Dec 2001 - 31 Dec 2007)	Period 3: Bear market (1 Jan 2008 - 30 Jun 2009)	Period 4: Bull market (1 Jul 2009 - 31 Dec 2012)

	Dependent variable $HE_{SPX, DH, p}$		Dependent variable $HE_{SPX, DH, p}$		Dependent variable $HE_{SPX, DH, p}$		Dependent variable $HE_{SPX, DH, p}$	
	Coefficients	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**	**Coefficients**	**P-value**
Int	1.6018***	<.0000	4.8063***	0.0001	0.8581	0.1690	-0.0202	0.9819
TV	-0.0091	0.3845	-0.1553***	0.0008	-0.0082***	0.0023	-0.0644*	0.0511
TM	-0.0954**	0.0125	-0.1619	0.3117	0.1542**	0.0397	0.4572***	<.0000
IV	0.1618	0.5878	1.3138*	0.0626	1.7683***	<.0000	2.3637***	<.0000
R^2	0.0643		0.0514		0.0455		0.0352	
No. of obs.	7,577		69,055		67,214		126,718	

***denotes statistical significance at the 1% level.
** denotes statistical significance at the 5% level.
* denotes statistical significance at the 10% level.

Note: The data covers the period 23 July, 2001 to 31 December 31, 2011. The results in this table are obtained by applying Eq. (23). Int stands for the intercept. TV is the logarithm value of the reading volume. TM is the logarithm value of the time to maturity. IV stands for the implied volatility calculated by applying the Black-Scholes model. No. of obs stands for the number of observations in the specific regression.

Chapter 6. Conclusion

Index option markets, which are used to hedge against movements in the overall market, have grown dramatically in the last few years. XEO and SPX are European-style index options written on two most active indexes (S&P 100 and S&P 500, respectively) in the US financial market. This thesis compares the hedging effectiveness of the XEO and SPX by constructing hedging portfolios using dynamic and static hedging strategies from July 23, 2001 to December 31, 2011. The previous literature suggests that the option market might show distinctive characteristics under different market cycles. The sample period in my research includes four market cycles, including the pre-crash bull market and the bear market around the 2008 financial crisis. Consequently, the sample has been divided into four sub-samples based on the US Business Cycle Expansions and Contractions report produced by the *NBER*, and the hedging effectiveness of XEO and SPX are compared under the different market cycles.

Overall, hedging using the SPX outperforms that using the XEO under both dynamic and static hedging strategies. The better hedging performance of the SPX, especially during the 2008 financial crisis, is presumably due to the high option trading volume associated with the SPX. Lower option trading volumes during the financial crisis might have caused the XEO to lose liquidity and induced a worse hedging performance. Moreover, the dynamic hedging strategy is more effective than the static hedging strategy. This is probably because, unlike dynamic hedging portfolios which are rebalanced daily, static hedging strategies involves initiating positions in the options which are maintained until the option expiration date, leading to higher risk from uncertain market movements. Furthermore, as the option time to maturity increases, the effectiveness of static hedging strategy declines, but the effectiveness of dynamic hedging strategy does not decrease sharply. Therefore, the results show less difference between the hedging effectiveness of short-term static hedging which uses options with expiration in ten days and that of dynamic hedging, suggesting that the poor performance of the static hedging strategy may largely be due to using options with a long time to maturity.

The possible influence of several variables has also been addressed in this research by analyzing the relationship between the hedging effectiveness of the XEO and the SPX and associated trading volume, time to maturity, and implied volatility. The results indicate that all of the three variables influence the hedging effectiveness. Higher trading volume is associated with better performance of the hedging portfolios, while longer time to maturity and higher implied volatility are associated with worse hedging performance.

Questions and topics for further research regarding the hedging effectiveness of index options still remain. First, more hedging strategies could be applied to compare the hedging effectiveness of the XEO and SPX. Second, more index options could be added into the comparisons, such as the OEX. Third, transaction costs could be addressed in the hedging strategies. Fourth, to better understand the possible reasons for the differences in the hedging effectiveness of the XEO and SPX, especially in different market cycles, more influential variables might be considered the multivariate regression analysis.

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Appendix

Table A1 Daily average option contract volume of the OEX from 23 July 2001 to 31 December 2011.

		OEX			
	Year	Trading days	Call	Put	Total
Period 1: Bear market 23 July-30 November 2001	2001	109	15828.68	19182.73	35011.41
Period 2: Bull market 1 December 2001–31 December 2007	2002	252	25399.55	27230.11	52629.66
	2003	252	27703.63	28933.33	56636.96
	2004	252	31760.37	33514.91	65275.28
	2005	252	34939.82	38080.17	73019.99
	2006	250	30597.73	37815.34	68413.07
	2007	249	24447.29	34536.53	58983.82
Period 3: Bear market 1 January 2008–30 June 2009	2008	251	20911.77	22447.65	43359.42
	2009	251	17230.75	18736.52	35967.27
Period 4: Bull market 1 July 2009–31 December 2011	2010	252	21341.63	20472.62	41814.25
	2011	252	10715.36	16272.73	26988.09